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Patterns of Care and Disparities in the Treatment of Early Breast Cancer

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14. ABSTRACT

Scope and Purpose. Prior research evidence that has suggested that regional variation and socioeconomic barriers in breast cancer treatment remain substantial problems for patients across the nation. The purpose of our project was to characterize national patterns in the treatment of early invasive breast cancer in older women with incident disease. We specifically sought to characterize variation in cost of cancer care across the nation.

Methods. We sought to apply a novel resource, comprehensive national Medicare claims data, to study cost variations in women treated for breast cancer. We first identified patients with invasive breast cancer treated with mastectomy or breast conserving surgery (BCS) and evaluated variations in breast cancer treatment utilization and resulting costs of treatment. Multivariate logistic and liniear regression was used to model these outcomes.

Findings. Significant regional variation in utilization of breast cancer treatment existed in our cohort of older women diagnosed with invasive disease, even after standardization for patient and disease characteristics. In addition, significant disparities in costs or spending for breast cancer existed, with not only patient and clinical factors playing a significant role in costs, but also socioeconomic factors.

Conclusions. Our research adds to the existing literature by providing the first comprehensive national sample to address these study questions. Our future research will extend on our current findings by determining whether these variations in breast cancer treatment also affect outcomes, such as cancer recurrence, mortality, and costs of cancer care.

15. SUBJECT TERMS

Breast cancer, Medicare, utilization, cost

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Table of Contents

Page

INTRODUCTION

The purpose of our project was to characterize national patterns in the treatment of early invasive breast cancer in older women with incident disease. We specifically sought to characterize disparities in care and regional variation in treatment patterns. Our study subject was in response to prior research evidence that has suggested that regional variation and socioeconomic barriers in breast cancer treatment remain substantial problems for patients across the nation. In fact, though in 1999, the Institute of Medicine National Cancer Policy Board issued a call to improve the quality of cancer care nationally[1], a recent study indicated that progress in overcoming disparities in cancer care has been insufficient[2]. For our project, we sought to apply a novel resource, comprehensive national Medicare claims data, to study disparities in care and outcomes in women with breast cancer. Our proposed project is intended to span a total of three years. At the culmination of Year 1 of this project, our main objective was to characterize the scope of treatment disparities and the magnitude of regional variation in care, using cross-sectional data. To date, at the culmination of Year 2, we have begun to additionally assess the factors that impact the choices for treatment—including non-standard and developing treatment—as well as the implications of these treatment choices on variations on spending (cost) in breast cancer care. Potential variations in costs of care are particularly of interest, given the increasing emphasis on the simultaneous goals of cost containment and optimization of outcomes in healthcare. As we anticipate Year 3, we intend to assess the impact of utilization patterns on breast cancer outcomes. The following narrative will detail results obtained from our project over the course of Year 2.

BODY

Task Summary from Statement of Work (SOW)

Task 2.

To assess initial and continuing care costs of breast cancer care.

Deliverable A: Preparation of abstract for national scientific meeting

Deliverable B: Preparation of manuscript for submission at peer-reviewed journal.

Objectives

1: To present overall national and state-by-state absolute and standardized utilization rates of mastectomy versus breast-conserving surgery (BCS)
2: To identify variations and disparities in use of mastectomy versus BCS
3: To quantify the costs associated with mastectomy and BCS, and to compare these costs with other breast cancer treatment related spending, including chemotherapy, radiotherapy, and other surgeries

4: To compare breast cancer associated costs with non cancer associated costs in the year after cancer diagnosis
5: To identify predictors of breast cancer-related costs, including treatment, disease, patient, and socioeconomic factors
6: To present utilization rates of brachytherapy, an emerging but potentially costly breast cancer treatment, in order to help quantify the diffusion of this technology in an emerging area of treatment across the United States and discuss the implications of findings on the future incorporation of costly treatments and technologies.

Methods

Study sample

To accomplish SOW Task 2, we focused our analyses on a study sample derived from the national Medicare dataset. The national Medicare dataset includes comprehensive claims information with beneficiary-specific data on all Medicare beneficiaries in the United States. Files contain data collected by Medicare for reimbursement of health care services for each beneficiary and include institutional (inpatient and outpatient) as well as non-institutional (physician or other providers) final action claims[3]. To define a cohort of patients with incident disease in 2003 required claims data spanning 2002 to 2004 to have complete information on the claims history the year prior to diagnosis and information on claims up a year after diagnosis, as detailed below.

In summary, our initial study population consisted of 853,273 women who had any diagnosis of invasive breast cancer in 2003, based on an International Classification of Diseases, Ninth Revision (ICD-9) diagnosis code of 174. As this denominator would have included incident and prevalent cases in 2003, we used the following algorithm to identify patients with incident breast cancer, treated with either breast-conserving surgery (BCS) or mastectomy. This method was based on a prior validated algorithm for claims data.[4, 5] We included women (age≥65 years) who had any diagnosis of invasive breast cancer in 2003 (defined as an International Classification of Diseases, Ninth Revision (ICD-9) diagnosis code of 174) who underwent BCS (N= 83,611) or mastectomy (N=42,504) between January 1, 2003, and December 31, 2003. From this sample, to increase the specificity of the definition, we excluded 23,715 patients who did not have at least 2 claims (on different dates) indicating a diagnosis of invasive breast cancer between January 1, 2003 and December 31, 2004 (at least 1 claim must have occurred during 2003), with no more than 6 months between the date of BCS or mastectomy and the earliest breast cancer diagnosis claim date. To exclude the prevalent cases, we excluded 16,471 patients who had a breast cancer–related diagnosis or procedure claim between January 1, 2002, and December 31, 2002. To reduce misclassification of the primary intended surgery, we excluded 630 patients who underwent both types of surgery (either date of mastectomy claim preceding date of BCS claim or mastectomy occurring more than 3 months after BCS), except for patients who received a mastectomy within 3 months of BCS for whom mastectomy was considered the definitive surgery. To limit our sample to patients with non-metastatic invasive breast cancer, we then excluded 2,122 patients who had two or more claims specifying metastatic breast cancer from 3 months before to 3 months after the diagnosis date. To improve sample homogeneity, we also excluded 5,719 patients who were receiving Medicare coverage because of end-stage renal disease or disability. Finally, to ensure we had complete claims information to determine patients' cancer treatment course and comorbidities, we excluded 6,612 patients who lacked Part A or B coverage or who had intermittent health maintenance organization coverage in the 9 months after or in the 1 year before their breast cancer diagnosis date (of these patients, 3,561 had incomplete information in the year prior to diagnosis because they were <66 years of age). For this analysis, the breast cancer diagnosis date was defined as the date of the earliest claim for a diagnosis of breast cancer. This left a final sample size of 56,725 patients. Our algorithm was based on a prior validated algorithm for identifying breast cancer patients using claims data[4].

Surgical treatment and other covariates

Covariates derived from Medicare files (denominator and claims files) included cancer treatment variables, other clinical variables, and demographic data. Patients were classified as treated with BCS or mastectomy if a claim for the surgery (Appendix A) occurred within 6 months of the breast cancer diagnosis date. Claims for chemotherapy must have occurred within 6 months and RT claims within 9 months of the breast cancer diagnosis date. These claims-based treatment definitions have been applied in prior studies of breast cancer patients.[6-11]

Other disease- and treatment-related variables included axillary lymph node involvement, axillary lymph node dissection, sentinel node biopsy, receipt of any RT (including brachytherapy), receipt of any chemotherapy, specific receipt of doxorubicin or paclitaxel, receipt of any imaging studies for staging, number of hospitalizations in the year after diagnosis, and number of medical oncology, radiation oncology, and surgery visits in the year after diagnosis. Of patients who received RT, patients were further classified as having received external beam radiation therapy (EBRT), brachytherapy, or both (EBRT plus brachytherapy boost), as indicated by claims codes. Patients treated with brachytherapy were further classified as having received balloon-based treatment if a procedure code was found specifying accordingly.

Variables indicating preventive healthcare and interactions with the healthcare system included mammography in the year prior to diagnosis and number of physician visits in the year prior to diagnosis. In addition, we calculated the severity of comorbid disease for each patient based on a modified Charlson comorbidity score validated in a prior claims-based study: 0 (no comorbidity), 1 (mild to moderate), or 2 or more (severe)[12]. This score combined comorbidities recorded in Medicare claims during the 12 months prior to the patient's cancer diagnosis. To enhance specificity of comorbid disease diagnoses, patients must have had at least 1 inpatient (Part A) claim or at least 2 outpatient (Part B) claims more than 30 days apart.[12]

Demographic data available through Medicare files included patient age at diagnosis, race (categorized as white, black, and other), and state and county of residence. Classification of geographic regions was based on Census Divisions definitions.[13] Socioeconomic variables, obtained from the 2003 Area Resource File (ARF)[14] and linked to the Medicare dataset by patients' county, included (by county of patient's residence) median household income, percent living below poverty level, percent completing ninth grade education, high school, and college. Supply of healthcare providers (for breast cancer treatment) was measured by the density of general surgeons, and density of radiation oncologists at county-level, obtained from the 2003 ARF.

Predictor covariates were obtained by searching through inpatient, outpatient, and carrier Medicare claims or the denominator file for SEER-Medicare linked data for demographic variables. A comprehensive list of International Classification of Diseases, Ninth Revision (ICD-9), Common Procedural Terminology (CPT), and Revenue Center codes for each predictor are listed in **Table 1**.

Cost

Total health care costs for each patient were calculated based on Medicare spending. Any claim, and the associated total payment amount reported by Medicare, identified through the inpatient, outpatient, or carrier claims files was added, for a sum total of costs in the year after breast cancer diagnosis. Breast-cancer related spending was summed for each patient with claims belonging in the following categories: surgery (mastectomy, BCS, or reconstruction after mastectomy), axillary nodal dissection or involvement, chemotherapy, radiotherapy, and other breast cancer diagnosis-related claim.

Statistical analyses

Statistical analyses were conducted using SAS version 9.1.3 (SAS Institute Inc, Cary, NC), and all statistical tests assumed a 2-tailed α of 0.05. Percent BCS versus mastectomy use was calculated for the entire sample, by state, and by region. Mean breast cancer-related and overall healthcare costs were calculated for the entire sample, by state, and by region. We then tested the unadjusted bivariate associations between receipt of BCS and treatment, clinical, demographic, and socioeconomic covariates using the Pearson chi-square (χ^2) test for categorical variables and the Wilcoxon rank sum test for continuous variables; as well as the unadjusted associations between cost and covariates using the Wilcoxon rank sum test. A multivariate logistic model tested adjusted associations with BCS and a multivariate linear regression model tested adjusted associations with breast cancer-related costs, with covariates for the final multivariate models selected *a priori* based on significance in bivariate analyses ($P<0.25$) and significance in prior studies of cancer patients[19-24] The final parsimonious model was selected based on statistical significance, goodness of fit, and minimizing multicollinearity.

Early stage breast cancer subgroup

Breast cancer stage is not directly available through Medicare claims data. To select a subgroup of patients with early stage breast cancer, given that surgical treatment strategies are typically dependent on disease stage, we applied a previously validated predictive algorithm that used claims-based covariates to identify patients with a high probability of having stage I or II disease.[15] Therefore, in the selected subgroup of 43,706 predicted early stage patients, we further examined the adjusted associations between receipt of BCS and covariates using multivariate logistic modeling.

In a secondary, validating analysis on this selected group of predicted early stage patients, we also identified the subgroup of 42,499 patients who did not have claims for axillary involvement and chemotherapy, as these patients would also be more likely to have early stage disease (kappa=0.73 for the two selected subgroups). The adjusted associations were compared in this group to the associations calculated for the predicted early stage patients.

Brachytherapy pilot subgroup

A limitation of the current national Medicare data-based cohort for our analysis is that, for the study of treatment patterns, this is essentially a cross-sectional sample (as the initial course of cancer treatment can occur months or even up to a year after the date of diagnosis). Thus, for the study of temporal patterns, the national Medicare data is particularly limited. Therefore, we sought to study a pilot sample derived from the The MarketScan® Medicare Supplemental database is a large, nationwide, employment-based claims database which includes Medicare beneficiaries with private supplemental insurance obtained through their former employers. We identified 6,882 women aged 65 years and older with a diagnosis of invasive breast cancer and treated with BCS. Using the same algorithm as listed above, patients who had claims for RT were further classified as having received as treated with external beam radiation therapy (EBRT), brachytherapy, or both (EBRT plus brachytherapy boost), as indicated by claims codes. Patients treated with brachytherapy were further classified as having received balloon-based treatment if a procedure code was found specifying accordingly. To address our second objective, we evaluated for a time trend using the Mantel-Hanszel chi-square and Cochran-Armitage tests for trend. We also benchmarked the time trends against two major policy events that occurred during the study period: Food and Drug Administration (FDA) approval of the first balloon-based brachytherapy device for breast cancer in June 2002; and Medicare reimbursement of breast brachytherapy in April 2004.

This pilot analysis was conducted in anticipation of long-term data in the larger national Medicare dataset in the next phase of this research study.

Table 1. Claims codes searched to calculate costs and define variables of interest

Variables	ICD-9 Diagnosis	ICD-9 Procedure	CPT	Revenue Center
Radiotherapy				
EBRT		9221-6, 9228, 9229	77427, 77431-2, 77401-9, 77411-14, 77416, 77418, 77470, 77499, 77520, 77522-3, 77525, 77750, 77789, 77790	0330, 0333
Brachytherapy		9227	19296-8, 77326-8, 77761-3, 77776-8, 77781-4, Q3001, C9714-5	
Balloon-based brachytherapy			C9714-5	
Extent of disease at diagnosis				
Axillary LN involvement	1963			
Metastatic disease	1962, 1965-6, 197, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 198, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 19881, 19882, 19889			

Table 1, *continued*

Variables	ICD-9 Diagnosis	ICD-9 Procedure	CPT	Revenue Center
Cancer diagnosis and treatment				
Imaging (CT, MRI, PET, or bone scan)		8801, 8703, 8741, 8891, 8896, 8874, 9218, 9214	70450, 70460, 70470, 70551-3, 71250, 71260, 71270, 72192-4, 74150, 74160, 74170, 76700, 78315, 78320, 78812-6, G0213-5	
Breast conserving surgery		8520-3,8525	19110, 19120, 19125, 19160, 19162	
Mastectomy		8541-8	19180, 19182, 19200, 19220, 19240	
Axillary surgery (LN dissection or sentinel node)		4023, 4051, 8543, 8547	38500, 38525, 38740, 38745, 38792, 19162, 19200, 19220, 19240, 78195	
Chemotherapy (any agent)	V581, V662, V672	9925	96400-96549, J9000-9, Q0083-5	0331, 0332, 0335
Preventive care and interaction with healthcare system				
No. physician visits				
Screening mammography	V7611, V7612	8737, 8736	77055-6, 77058-9, 76090-2, G0202, G0204, G0206	0401, 0403
Influenza vaccine	V0481		90658, G0008	
General health status				
Charlson comorbidity score[a]				

Abbreviations: CPT Common Procedural Terminology; ICD International Classification of Diseases; LN lymph node; No. number.

[a] Klabunde CN, et al. J Clin Epidemiol 2000;53:1258-1267.

Results

Patient characteristics and treatment course

Our cohort consisted of 56,725 women with incident, invasive breast cancer diagnosed in 2003 and treated with surgery. In our sample, median age was 76 (interquartile range 71 to 81). Ninety percent (N=51,432) were white, 7% (N=3,727) were black, and 3% (N=1,566) were of other race. As a component of the initial treatment course, the majority of patients were treated with BCS. Specifically, 59% of patients (N=33,450) received BCS, while 41% (N=23,275) underwent mastectomy. Additionally, of the entire sample, 50% received RT and 16% received chemotherapy. Of BCS patients, 74% received RT and 13% received chemotherapy. Of mastectomy patients, 14% received RT and 23% chemotherapy.

Predictors of BCS versus mastectomy use

The use of BCS was associated with both clinical and non-clinical factors. In the entire sample, on unadjusted analysis, patients who were younger, white, and had fewer comorbidities, lymph node-negative disease, and predicted early stage disease were more likely to undergo BCS. Patients who did not receive chemotherapy or did not undergo axillary surgery were also more likely to undergo BCS (**Table 2**). In addition, neighborhood socioeconomic factors were also highly associated with BCS. Specifically, patients living in metropolitan areas and in counties with higher median household income, lower percent living below poverty level, and higher percent with college education were more likely to undergo BCS. Of patients living in non-metropolitan areas, only 51% underwent BCS. Supply of healthcare providers also influenced treatment, with BCS use more likely in patients residing in counties with a higher density of surgeons and radiation oncologists (**Table 2**). Finally, significant geographic variation existed (P<0.001), with patients in the Northeast and Pacific West most likely to undergo BCS. In contrast, patients in the South were least likely to undergo BCS, with half or fewer of all patients in these regions treated with BCS (**Figure 1, Table 3)**. On adjusted analysis, higher density of surgeons was no longer a significant predictor of BCS use (P=0.13), specifically once the multivariate model accounted for geographic region. However, a higher density of radiation oncologists remained a significant predictor of BCS use (P=0.01). (**Table 4**).

Early stage breast cancer subgroup

In the selected subgroup of 43,706 patients with predicted early stage (Stage I or II) disease (77% of the entire sample), a total of 68% (29,828 of 43,706) of this selected group received BCS. This was consistent with a total of 65% (27,544 of 42,499) received BCS in the validation subgroup of patients who did not have axillary involvement and did not receive chemotherapy. Geographic variation persisted in the use of BCS for patients with predicted early stage. Patients in the Northeast (78-79%) and Pacific West (71%) were still the most likely to undergo BCS, while patients in the South (57-59%) and portions of the Midwest (58%) were the least likely (**Table 3**). The validation subgroup was similar, with BCS ranging from 54% (South) to 75% (Northeast). On adjusted analysis, significant predictors of BCS use included similar demographic, clinical, and socioeconomic factors as predictors for the entire sample

(**Table 4**). Significant predictors of BCS use identified in the validation group for early stage breast cancer were also consistent with this analysis.

Table 2. Predictors of treatment utilization

Patient Characteristic	% Treated with BCS (N)	% Treated with Mastectomy (N)	*P*
Demographic			
Age, mean (standard deviation)	76 (7)	77 (7)	**<0.001**
66 to <70 years	63 (7,112)	37 (4,260)	**<0.001**
≥70 years	58 (26,338)	42 (19,015)	
Race			
White	59 (30,572)	41 (20,860)	**<0.001**
Black	54 (2,026)	46 (1,701)	
Other	54 (852)	46 (714)	
Clinical			
Charlson comorbidity score			
0 comorbid conditions	61 (22,735)	39 (14,578)	**<0.001**
1 comorbid condition	57 (6,414)	43 (4,875)	
2 or more comorbid conditions	54 (2,673)	46 (2,314)	
Unknown	52 (1,628)	48 (1,508)	
Disease Stage and Treatment			
Predicted early stage (stage I or II) disease	68 (29,828)	32 (3,622)	**<0.001**
Axillary lymph node positive disease	37 (17,587)	63 (30,050)	**<0.001**
Lymph node-negative disease	63 (5,688)	37 (3,400)	
Axillary lymph node dissection	42 (11,995)	58 (16,715)	**<0.001**
No axillary dissection	77 (21,455)	23 (6,560)	
Radiation therapy	88 (24,823)	12 (3,358)	**<0.001**
No radiation therapy	30 (8,627)	70 (19,917)	
Chemotherapy	44 (4,299)	56 (5,447)	**<0.001**
No chemotherapy	62 (29,151)	38 (17,828)	
Healthcare access*			
Median surgeon density† (IQR)	11 (8-16)	10 (6-15)	**<0.001**
Median radiation oncologist density‡ (IQR)	13 (4-20)	11 (0-19)	**<0.001**
Socioeconomic status*			
Living in metropolitan area	62 (25,979)	38 (16,132)	**<0.001**
Living in non-metropolitan area	51 (7,193)	49 (6,971)	
Median income (IQR)	41,691 (36,221-48,059)	39,879 (34,267-45,922)	**<0.001**
Median percent living in poverty (IQR)	10.7 (8-14)	11.4 (9-14)	**<0.001**
Median percent with college education (IQR)	24 (17-29)	22 (15-28)	**<0.001**

Abbreviations: BCS breast-conserving surgery; IQR interquartile range

* By patient county of residence

† Per 100,000 persons

Figure 1. Percent use of breast-conserving surgery (BCS) by state. Darker shading represents higher frequency of use.

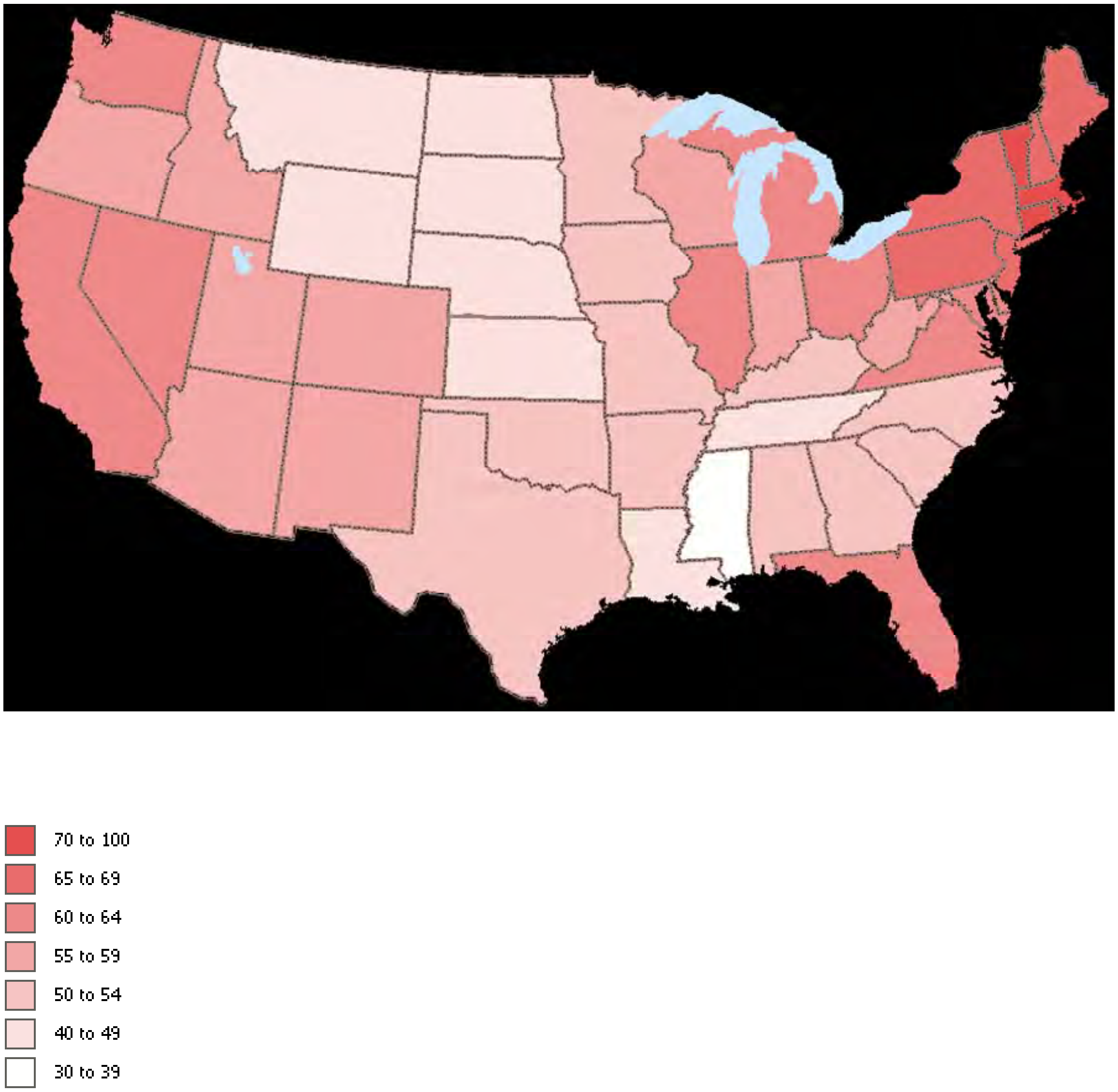


Table 3. Unadjusted and adjusted percent use of breast-conserving surgery (BCS) versus mastectomy by geographic region.

		% BCS (N=23,275)			% Mastectomy (N=33,450)		
Region	States	Overall	Adjusted*	Early Stage	Overall	Adjusted*	Early Stage
West, Pacific West	AK, CA, HI, OR, WA	62	62	71	38	38	29
West, Mountain West	AZ, CO, ID, MT, NV, NM, UT, WY	57	58	66	43	42	34
Midwest, West North Central	IA, KS, MN, MO, NE, ND, SD	50	51	58	50	49	41
Midwest, East North Central	IL, IN, MI, OH, WI	61	60	70	39	40	30
Northeast, New England	CT, MA, NH, ME, RI, VT	70	63	79	30	36	21
Northeast, Mid-Atlantic	NJ, NY, PA	67	64	78	33	35	22
South, South Atlantic	DE, DC, FL, GA, MD, NC, SC, VA, WV	59	59	68	41	41	32
South, West South Central	AK, LA, OK, TX	50	54	59	50	45	41
South, East South Central	AL, KY, MS, TN	48	51	57	52	48	43

Abbreviations: BCS breast-conserving surgery

* Adjusted for covariates including age, race, comorbidity score, axillary lymph node involvement, axillary dissection, chemotherapy, screening mammography, physician visits, surgeon density, radiation oncologist density, metropolitan area, poverty, education.

Table 4. Multivariate logistic model: Predictors of utilization of breast-conserving surgery.

	Entire sample				Early stage subgroup			
Covariate	**OR**	**95% CI**		***P***	**OR**	**95% CI**		***P***
Age 66 to <70 years vs. ≥70 years	1.37	1.31	1.44	**<0.001**	1.15	1.09	1.22	**<0.001**
Race								
White vs. black race	1.14	1.05	1.23	**<0.001**	0.95	0.86	1.04	0.26
White vs. other race	1.29	1.15	1.45	**<0.001**	1.17	1.08	1.27	**<0.001**
Charlson comorbidity score								
0 vs. 1 comorbid conditions	1.18	1.13	1.24	**<0.001**	1.21	1.15	1.28	**<0.001**
0 vs. 2 or more comorbid conditions	1.38	1.29	1.47	**<0.001**	1.17	1.08	1.27	**<0.001**
0 vs. unknown comorbid conditions	1.12	1.01	1.25	**0.03**	0.91	0.79	1.05	0.20
Lymph node-negative disease	1.60	1.52	1.68	**<0.001**	-	-	-	-
No axillary lymph node dissection*	4.00	3.85	4.17	**<0.001**	4.65	4.46	4.88	**<0.001**
No chemotherapy*	1.32	1.25	1.39	**<0.001**	0.63	0.57	0.69	**<0.001**
Screening mammography§	2.02	1.87	2.17	**<0.001**	0.89	0.80	1.00	**0.04**
1 or more visits to physician§	1.43	1.22	1.68	**<0.001**	1.97	1.60	2.43	**<0.001**
Geographic Region[‖]								
West, Pacific West	0.86	0.78	0.95	**0.008**	0.81	0.72	0.92	**0.001**
West, Mountain West	0.71	0.63	0.80	**<0.001**	0.69	0.60	0.80	**<0.001**
Midwest, West North Central	0.50	0.45	0.55	**<0.001**	0.45	0.40	0.51	**<0.001**
Midwest, East North Central	0.80	0.73	0.88	**<0.001**	0.75	0.67	0.84	**<0.001**
Northeast, Mid-Atlantic	1.05	0.95	1.16	0.34	1.06	0.94	1.19	0.36
South, South Atlantic	0.76	0.69	0.83	**<0.001**	0.69	0.62	0.78	**<0.001**
South, West South Central	0.58	0.53	0.65	**<0.001**	0.54	0.48	0.61	**<0.001**
South, East South Central	0.51	0.45	0.57	**<0.001**	0.45	0.39	0.52	**<0.001**
Surgeon density[†]	1.00	0.99	1.01	0.13	1.00	0.99	1.01	0.14
Radiation oncologist density[§]	1.30	1.06	1.59	**0.01**	1.37	1.07	1.75	**0.01**
Living in metropolitan area	1.20	1.14	1.26	**<0.001**	1.20	1.13	1.27	**<0.001**
Percent living in poverty < 11%[ǀ]	1.05	1.00	1.09	**0.03**	1.05	1.00	1.11	0.06
Percent with college education > 23%[ǀ]	1.13	1.08	1.19	**<0.001**	1.15	1.09	1.21	**<0.001**

Abbreviations: CI confidence interval, OR odds ratio

* A model excluding axillary lymph node dissection and chemotherapy, which are treatments likely to occur concurrently or after surgery, did not affect risk estimates for other covariates.

† Increased odds per 1 surgeon per 100,000 persons

§ Increased odds per 1 radiation oncologist per 10,000 persons

[ǀ] Continuous variables dichotomized at the median value

[ǀǀ] Compared with reference category Northeast New England. The Likelihood ratio test for all strata of the variable for region was statistically significant (P<0.001).

Costs of cancer and non-cancer care

In the year following diagnosis, the median breast cancer care-related costs (as reimbursed by Medicare) was $6,101 (interquartile range [IQR] $2,900 to $13,058). The most costly contributor to these costs was surgery-related costs (**Table 5**). These cancer-related costs compare with the median overall health care costs of $12,274 (IQR $7,623 to $19,041) and median non-cancer-related costs of $4,376 (IQR $668 to $9042). There was a significant correlation between cancer-related costs and overall health care costs in our sample (Pearson's R= 0.56, P<0.001).

Table 5. Median costs of breast cancer care

Category	Median costs ($)	IQR	Mean(SD)
Total breast cancer-related costs	6,101	2,900 - 13,058	9,973 (11,726)
Surgery			
Breast conserving surgery	411	163 - 865	727 (1,400)
Mastectomy	626	163 - 1,017	1,098 (1,783)
Axillary treatment	643	212 - 1,086	1,097 (2,007)
Reconstruction	1,045	210 - 2,171	1,511 (1,729)
Chemotherapy	895	205 - 3,401	2,524 (4,055)
Radiotherapy	2,042	1,105 - 4,489	3,136 (3,329)
Other/ Unspecified	3,344	1,597 - 6,859	5,770 (7,471)

Abbreviations: IQR interquartile range, SD standard deviation

Our data further demonstrated that there was significant geographic variation in breast cancer-related costs (P<0.001) (**Table 6**, **Figure 2**). In particular, there appeared to be lower cancer-related spending in the Southeastern region of the US and parts of the Midwestern US (**Table 6**) (P<0.001). This geographic variation appeared to correlate with variation in overall healthcare costs, with overall spending also lowest in the Southeastern US.

Other predictors were also found to have a significant correlation with breast cancer-related costs on univariate analysis. Not surprisingly, treatment utilization with any treatment modality (surgery, chemotherapy, or radiotherapy) was associated with increased costs. In addition, other clinical variables showed strong associations, including indicators of greater disease involvement such as axillary disease (nodal involvement). Patient factors also were associated, with younger women with fewer comorbidities more likely to incur breast cancer related costs. Interestingly, however, socioeconomic variables also demonstrated associations, with patients who were white, had higher income and higher education, and lived in a metropolitan area more likely to incur breast cancer related costs (**Table 7**). These variables remained significant on multivariate analysis.

Table 6. Geographic variation in breast cancer-related costs and overall costs (in $).

	Breast Cancer-Related			Overall		
States	Median ($)	IQR 25th	IQR 75th	Median ($)	IQR 25th	IQR 75th
AK, CA, HI, OR, WA	6,367	2,993	13,166	13,079	8,224	19,452
AZ, CO, ID, MT, NV, NM, UT, WY	6,480	3,108	13,409	11,875	7,561	17,971
IA, KS, MN, MO, NE, ND, SD	5,076	2,636	11,368	10,885	6,501	16,094
IL, IN, MI, OH, WI	5,993	2,971	12,817	12,255	7,770	18,719
CT, MA, NH, ME, RI, VT	6,025	2,993	12,933	12,596	8,616	17,650
NJ, NY, PA	6,568	2,962	13,677	13,474	8,662	20,748
DE, DC, FL, GA, MD, NC, SC, VA, WV	6,300	2,997	13,797	12,656	7,837	20,219
AK, LA, OK, TX	6,541	2,919	13,112	11,612	7,069	19,207
AL, KY, MS, TN	5,018	2,424	11,502	10,804	6,304	16,785

Figure. Breast-cancer related costs across the United States

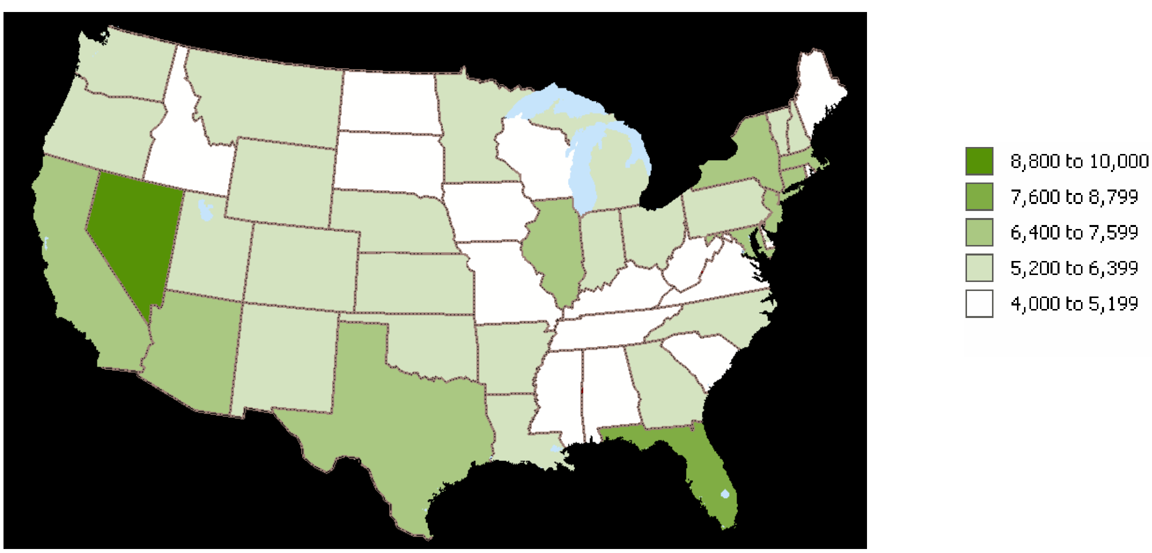


Table 7. Predictors of breast cancer-related spending

Patient Characteristic	Median Cost ($)	*P*
Demographic		
Age		
66 to <70 years	8,120	**<0.001**
≥70 years	5,670	
Race		
White	6,123	**0.03**
Black	5,952	
Other	5,766	
Clinical		
Charlson comorbidity score		
0 comorbid conditions	6,077	**<0.001**
1 comorbid condition	5,675	
2 or more comorbid conditions	5,887	
Unknown	9,652	
Disease Stage and Treatment		
Breast-conserving surgery	7,132	**<0.001**
Mastectomy	4,530	
Axillary lymph node positive disease	12,022	**<0.001**
Lymph node-negative disease	5,514	
Axillary lymph node dissection	7,564	**<0.001**
No axillary dissection	4,885	
Post-mastectomy reconstruction	8,890	**<0.001**
No post-mastectomy reconstruction	6,037	
Radiation therapy	10,087	**<0.001**
No radiation therapy	3,208	
Chemotherapy	18,512	**<0.001**
No chemotherapy	5,012	
Healthcare access*		
Surgeon density† (Pearson's R)	0.00036	0.93
Radiation oncologist density‡ (Pearson's R)	0.016	**0.0002**
Socioeconomic status*		
Living in metropolitan area	6,326	**<0.001**
Living in non-metropolitan area	5,371	
Income (Pearson's R)	0.034	**<0.001**
Percent with college education (Pearson's R)	0.021	**<0.001**

Abbreviations: BCS breast-conserving surgery

* Defined by patient county of residence

† Per 100,000 persons

‡ Per 10,000 persons

Brachytherapy utilization and pilot longitudinal subgroup

Of all patients from the national Medicare dataset treated BCS, 97% were treated with external beam radiotherapy (EBRT) alone, 3% with brachytherapy alone, and <1% with EBRT plus brachytherapy boost. For patients treated with brachytherapy, 98% received interstitial therapy and 2% intracavitary therapy. Though percent utilization of brachytherapy modalities ranged from 1% to 4% across different locations in the US, no statistically significant variation was detected by state (P=0.62) or by region (P=0.32). In addition, brachytherapy use did not differ by race (P=0.63) or age (P=0.59).

Of the entire sample, 5% (333 of 6,882) received brachytherapy alone (multi-catheter or balloon-based), 95% (6,521 of 6,882) received EBRT, and <1% (28 of 6,865) received EBRT plus brachytherapy boost. Treatments with brachytherapy alone significantly increased over time, from <1% in 2001, 2% in 2002, 3% in 2003, 5% in 2004, 8% in 2005, and 10% in 2006 (P<0.001) (**Table 8**). The most notable increases could be benchmarked against two major policy events: First, an increase in use was noted after July 2002, correlating with FDA approval of the balloon-based breast brachytherapy device (June 2002); and also, a further increase was noted after July 2004, correlating with Medicare reimbursement of treatment (April 2004) (**Figure 3**). Of patients treated with any form of brachytherapy alone, the proportion who received balloon-based treatment also increased dramatically over time, with 89% receiving balloon-based treatment by 2006 (**Figure 4**). In multivariate analysis, the temporal trend indicating a steady increase in the use of brachytherapy remained significant (P<0.001).

Table 8. Temporal trends in brachytherapy utilization

Time period	Total	% with EBRT only	(N)	% with EBRT + Boost	(N)	% Brachytherapy only	(N)
1/1/2001 – 6/30/2001	183	98.91	181	0.00	0	1.09	2
7/1/2001 – 12/30/2001	363	98.90	359	0.55	2	0.55	2
1/1/2002 – 6/30/2002	469	99.36	466	0.21	1	0.43	2
7/1/2002 – 12/30/2002	494	96.76	478	0.20	1	3.04	15
1/1/2003 – 6/30/2003	711	97.19	691	0.14	1	2.67	19
7/1/2003 – 12/30/2003	828	96.14	796	0.48	4	3.38	28
1/1/2004 – 6/30/2004	874	94.62	827	0.34	3	5.03	44
7/1/2004 – 12/30/2004	851	94.48	804	0.24	2	5.29	45
1/1/2005 – 6/30/2005	942	91.83	865	0.85	8	7.32	69
7/1/2005 – 12/30/2005	534	91.57	489	0.37	2	8.05	43
1/1/2006 – 6/30/2006	633	89.26	565	0.63	4	10.11	64
Total	6882	94.75	6521	0.41	28	4.83	333

Figure 3. Temporal trends: Percent of patients treated with brachytherapy (multi-catheter or balloon-based) as the sole modality of radiotherapy after breast-conserving therapy. Year 'a' refers to January through June and 'b' July through December. (P<0.001)

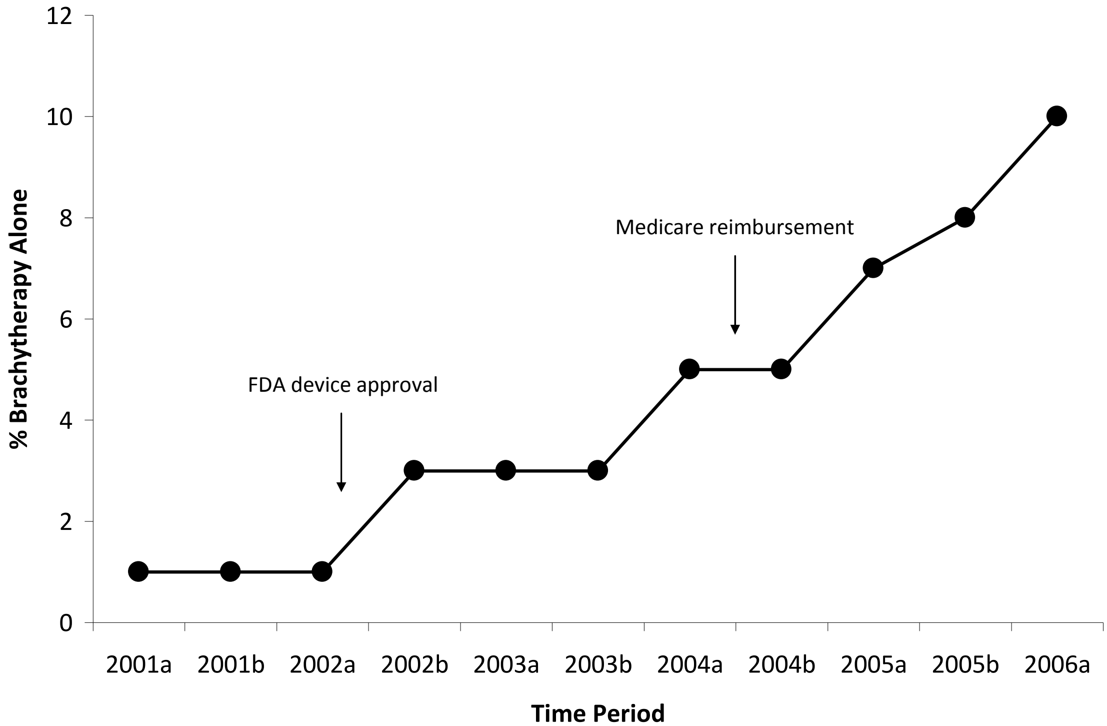
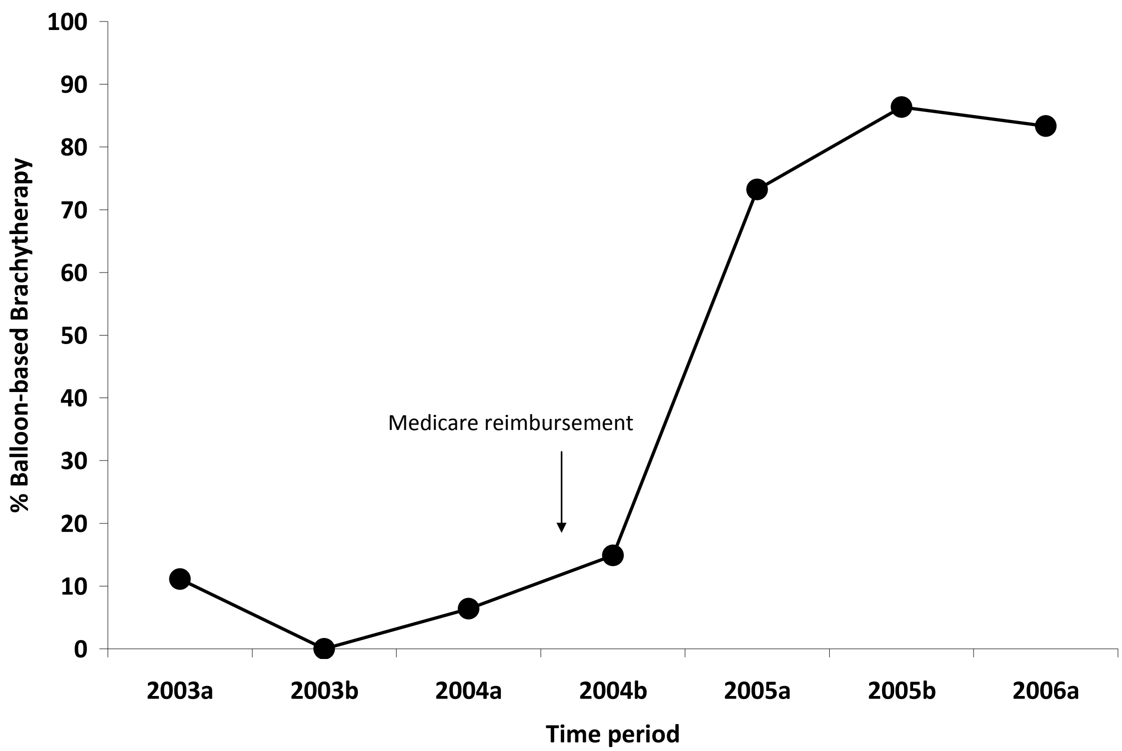


Figure 4. Temporal trends: Percent of patients treated with brachytherapy as the sole modality of radiotherapy after breast-conserving therapy that received balloon-based brachytherapy. Year 'a' refers to January through June and 'b' July through December. (P<0.001)



Discussion

Summary, Comments, and Future Work

In this contemporary, national cohort of older patients, we found that, overall, a majority of surgically treated patients with invasive breast cancer received BCS rather than mastectomy—59% of the entire sample and up to 68% of those with predicted early stage disease. However, we found considerable variations in BCS utilization by several important factors. First, clear regional differences existed. While in some regions an exceptionally high percentage of patients received BCS (up to 79% in predicted searly stage patients in the Northeast), still only about half of patients in areas of the South received BCS. Second, neighborhood socioeconomic characteristics also appeared to influence BCS utilization, with the presence of county-level poverty and lower education levels both associated with lower utilization of BCS. Furthermore, healthcare access also appeared to influence treatment patterns, with patients living in metropolitan areas and areas with a higher density of radiation oncologists more likely to receive BCS. Surgeon density, however, did not appear to influence BCS versus mastectomy use.

Prior studies of patients treated in earlier eras—the 1980's and 1990's—reported lower rates of BCS use compared with these more contemporary results, as low as 12% use of BCS just after the initial publication of the NSABP-B06 trial in 1985.[16-18] Steady increases have occurred in BCS use,[19, 20] however studies have consistently found that the majority of patients with invasive breast cancer in the United States have been treated with mastectomy. For example, a more recent study by Morrow et al. [21] found that, in 1994, BCS utilization was still only 43% in patients with stage I or stage II breast cancer across the United States. Continued evidence has accumulated providing increasingly convincing data that BCS plus radiotherapy is comparable to mastectomy in early stage patients, [22, 23] likely prompting the increase in overall frequency of BCS. Future studies, however, may seek to determine how trends in mastectomy versus BCS continue to evolve. Recent data suggest a reversal in utilization trends may be occurring, with an increasing number of patients receiving mastectomy, potentially influenced by changing technologies in breast cancer care, such as the use of breast magnetic resonance imaging (MRI).[24] Alternatively, the convenience of other emerging technologies such as accelerated partial breast irradiation and hypofractionated whole breast irradiation may increase the frequency of breast conservation.

Geographic and socioeconomic variation in treatment patterns was of interest. In prior studies of patients treated in earlier eras, results demonstrated that socioeconomic factors such as non-white race, lower income, higher poverty levels, and lower education were significant barriers to receipt of BCS.[25] Our analysis of the early stage disease subgroup suggests that racial differences in treatment for black patients and white patients may have decreased compared with prior studies.[19] Unfortunately however, the persistent finding of the other socioeconomic barriers in our contemporary cohort suggest that little progress has been made in overcoming disparities in the use of breast conserving therapy, particularly for patients living in the most disadvantaged neighborhoods and regions. Notably, a unique finding of our study was that the supply of radiation oncologists (as measured by the density of radiation oncologist by county) was a major factor affecting the choice to pursue BCS. Other than geographic region, this socioeconomic variable had the largest effect size for association with surgical treatment choice. Prior studies have noted that increased distance from radiation oncologist is a barrier to treatment with BCS.[26, 27] Similarly, our result supports the hypothesis that access to radiation oncologists continues to be an important factor that may affect both patients' and physicians' decision-making regarding surgical treatment.

Clinical and non-clinical variations in breast cancer-related costs were also of interest. Increased spending appeared to reflect adherence to standard treatment (for example, the use of RT after BCS) and higher socioeconomic status. A major limitation to our analysis is that no out of pocket costs were accounted for. In addition, oral medications (for example, hormonal therapy) were not included. Future studies of breast cancer related costs will include an analysis of longitudinal changes in spending on breast cancer and how spending may be associated with cancer outcomes.

The study of patterns of utilization of brachytherapy was also of interest. Brachytherapy is a radiation treatment administered through local implantation of a radioactive source. In recent years, brachytherapy has emerged as an important technique for the delivery of partial breast irradiation following breast-conserving surgery (BCS)—particularly in selected breast cancer patients with low-risk features such as smaller tumor size and node-negative disease. In these patients, either multiple interstitial catheters or a single balloon catheter are placed, allowing the radiation treatment to be delivered locally to tissue at the highest risk for recurrence. Compared with a standard course of external beam radiation treatment (EBRT) to the whole breast, a brachytherapy course is typically several weeks shorter, thereby reducing inconvenience associated with radiation treatment.

Yet the use of breast brachytherapy as the sole radiation treatment after BCS remains controversial. EBRT to the whole breast after BCS is widely accepted as the definitive, standard therapy for early stage disease, based on extensive randomized studies. Data have accumulated demonstrating local control and survival benefits attributable to EBRT over follow-up as long as twenty years.[22, 23, 28, 29] In contrast, Phase III trials directly comparing breast brachytherapy to standard EBRT after BCS have yet to mature.[30] Moreover, existing Phase II studies of breast brachytherapy have generally included relatively small sample sizes and have limited median follow-up times, typically about three to five years.[31-37]

Although it appears that, in the community setting, there is ongoing use of breast brachytherapy after BCS, the actual frequency of utilization has not been previously documented. Additionally, the factors influencing its use have not been previously studied. The lack of studies on breast brachytherapy utilization patterns is surprising, given that substantial controversy exists over its current use in the community setting. Specifically, some experts have considered this treatment strategy still unproven due to the existing gaps in the scientific literature regarding its efficacy.[38] Further, others considered this strategy one of the costlier options for patients with candidate low-risk tumors treated in the era of its initial diffusion.[39]

Thus, our documenting the pattern by which this novel—but also potentially unproven and costly—treatment has diffused into the care of breast cancer patients across the United

States offers a unique opportunity to help clinicians and policy makers better understand how clinical factors, policy factors, and socioeconomic factors influence the dissemination of new technologies into the health care system. In an era when new technologies and therapies are advancing rapidly, yet simultaneously, demands are growing to contain costs and establish treatment effectiveness, it is important to analyze available data to understand how decisions are made to employ developing treatments such as breast brachytherapy. Insights gained may help to improve the rationale by which future therapies are promoted and adopted into care.

KEY RESEARCH ACCOMPLISHMENTS

- Conducted univariate and multivariate data analysis.
- Further conducted stratified and subsidiary analyses, including an analysis of the disparities in treatment and costs by clinical and non-clinical factors
- Preparation of manuscripts in progress, for submission at peer-reviewed journals

REPORTABLE OUTCOMES

Manuscripts

Smith GL, Xu Y, Shih YCT, Giordano SH, Smith BD, Hunt KK, Strom EA, Perkins GH, Hortobagyi GN, Buchholz TA.. Breast-conserving surgery in older patients with invasive breast cancer: Current patterns of treatment across the United States. 2009 Accepted for publication at J Am Coll Surg.

Smith GL, Shih YT, Xu Y, Giordano SH, Smith BD, Perkins G, Tereffe W, Woodward WA, Buchholz TA. Racial disparities in treatment for early invasive breast cancer: a national Medicare study of radiotherapy after conservative surgery. Cancer 2009. In press.

Smith GL, Shih YT, Xu Y, Giordano SH, Smith BD, Buchholz TA. Breast brachytherapy in the United States: How is this emerging modality being incorporated into the care of older breast cancer patients? In submission.

Smith GL, Shih YT, Giordano SH, Smith BD, Buchholz TA. Predicting breast cancer tumor stage using Medicare claims data. 2009. Under review at Epidemiologic Perspectives & Innovations.

Abstracts and presentations

Smith GL, Xu Y, Buchholz TA, Smith BD, Giordano SH, Shih YCT. Breast brachytherapy in the United States: utilization patterns in older patients after breast-conserving surgery. Abstract 2009. Accepted for oral presentation: American Society of Therapeutic Radiology and Oncology

Smith GL, Shih YT, Xu Y, Giordano SH, Smith BD, Buchholz TA. Breast brachytherapy in the United States: How is this emerging modality being incorporated into the care of older breast cancer patients? Abstract 2008. (Poster presentation: San Antonio Breast Cancer Symposium)

Awards and Recognition

July 2009 Smith GL, et al. “Breast-conserving surgery in older patients with invasive breast cancer: Current patterns of treatment across the United States” manuscript to be highlighted in the October continuing medical education (CME) issue of J Am Coll Surg

June 2008 to present

M. D. Anderson Cancer Center Odyssey Fellow Award, to support the best postdoctoral trainees among the newest generation of cancer researchers at the institution

Updated CV, SEE APPENDIX.

CONCLUSION

At the conclusion of Year 2 of our research, we have made significant progress toward accomplishing our project goals. Specifically, we have worked to accomplish the objectives stated for Year 2 in the Statement of Work. Using our novel, comprehensive national Medicare dataset, we conducted several retrospective analyses on a cohort of older women diagnosed with early invasive breast cancer. Results from our analyses provided novel insights that contribute to the existing scientific literature. The most striking results from our analyses suggest that variation in breast cancer care is significant, and these variations appear to contribute to variations in costs for breast cancer care across the United States. The future direction of work will be to understand whether disparities in outcomes occur due these variations in utilization and spending.

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APPENDIX. CURRICULUM VITAE

Grace Li Smith, M.D., Ph.D., M.P.H.

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Background

Born March 1977 in Silver Spring, Maryland
Married May 1998 to Benjamin D. Smith, MD

Career Goals

To integrate my training in epidemiologic research and clinical medicine as a physician-scientist in the field of radiation oncology

Education and Training

2007-present	**University of Texas M.D. Anderson Cancer Center**, Houston, TX Postdoctoral Fellow, Department of Radiation Oncology Odyssey Fellow, 2008-present
2001-2007	**Yale University School of Medicine, Medical Scientist Training Program (MSTP)**, New Haven, CT Doctorate of Medicine, 2005, *cum laude* **Yale University Graduate School of Arts and Sciences, Division of Epidemiology** Doctorate of Philosophy, 2007 Masters of Philosophy, 2005, *distinguished*
2005-2006	**Yale-New Haven Hospital**, New Haven, CT Intern, Department of Internal Medicine
1998-2000	**Yale University School of Public Health, Division of Chronic Disease Epidemiology** Masters in Public Health, 2000
1994-1998	**Rice University**, Houston, TX Bachelor of Arts in Biology and in Sociology, 1998, *summa cum laude, Phi Beta Kappa*

Honors and Awards

2008	American Society of Clinical Oncology (ASCO) Breast Cancer Symposium Merit Award
2008	M. D. Anderson Cancer Center Odyssey Fellow Award, to support the best postdoctoral trainees among the newest generation of cancer researchers at the institution
2008	Susan G. Komen Houston Affiliate Travel Scholarship, to support participation at the American Society of Clinical Oncology 2008 Breast Cancer Symposium
2006	Original 1st-author paper featured in Nature Clinical Practice Nephrology: **Smith GL**, et al. Arch Intern Med. 2006 May 22;166(10):1134-42.
2005	Comprehensive exams for Ph.D. passed with *distinguished* honors, for achieving the highest possible score in epidemiology, biostatistics, and specialty area exams
2005	American Cancer Society Prize, awarded for the outstanding M.D. thesis in cancer
2005	Farr Scholar, awarded for excellence in research, leadership and creativity in pursuit of medical knowledge as a Yale medical student
2005	Campbell Prize, awarded for the highest score on Step Two of the USMLE for graduating students of Yale University School of Medicine
2005	American Medical Women's Association Glasgow Memorial Achievement Citation, awarded for outstanding women graduates of Yale University School of Medicine
2004-2005	American Heart Association, Kidney in Cardiovascular Disease Council writing committee
2003	Co-Chair for educational session, American College of Cardiology national scientific meeting
1998-2000	Scholarship for academic excellence for Yale School of Epidemiology and Public Health

1998	Phi Beta Kappa
1994	Max Roy scholarship for academic excellence, Rice University
1994	National Merit Scholar
1994	Valedictorian, Quince Orchard High School

Publications & Presentations

Commentaries and Review Article

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2. **Smith GL,** Buchholz TA. Commentary on "Radiotherapy following breast-conserving surgery for screen-detected ductal carcinoma in situ: indications and utilisation in the UK. Interim findings from the Sloane Project" Dodwell et al. Br J Cancer 97:725-9, 2007. Breast Diseases Quarterly 2008; 19:168.

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5. **Smith GL,** Buchholz TA. Commentary on "Correlates and Effect of Suboptimal Radiotherapy in Women with Ductal Carcinoma In Situ or Early Invasive Breast Cancer" Gold et al. Cancer 2008 113: 3108-15. Breast Diseases Quarterly 2009; 20:204.

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1. **Smith GL,** Xu Y, Shih YCT, Giordano SH, Smith BD, Hunt KK, Strom EA, Perkins GH, Hortobagyi GN, Buchholz TA.. Breast-conserving surgery in older patients with invasive breast cancer: Current patterns of treatment across the United States. 2009 Accepted for publication at J Am Coll Surg.

2. **Smith GL,** Shih YT, Xu Y, Giordano SH, Smith BD, Perkins G, Tereffe W, Woodward WA, Buchholz TA. Racial disparities in treatment for early invasive breast cancer: a national Medicare study of radiotherapy after conservative surgery. Cancer 2009. In press.

3. Smith BD, **Smith GL**, Hurria A, Buchholz TA. The future of cancer incidence in the United States: Expected burdens upon an aging, changing nation. Accepted for publication Journal of Clinical Oncology 2009.

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In Progress

1. **Smith GL**, Shih YT, Xu Y, Giordano SH, Smith BD, Buchholz TA. Breast brachytherapy in the United States: How is this emerging modality being incorporated into the care of older breast cancer patients? In submission.

2. **Smith GL**, Shih YT, Giordano SH, Smith BD, Buchholz TA. Predicting breast cancer tumor stage using Medicare claims data. 2009. Under review at Epidemiologic Perspectives & Innovations.

Abstracts and Presentations at National Scientific Meetings:

1. **Smith GL**, Xu Y, Buchholz TA, Smith BD, Giordano SH, Shih YCT. Breast brachytherapy in the United States: utilization patterns in older patients after breast-conserving surgery. Abstract 2009. Accepted for oral presentation: American Society of Therapeutic Radiology and Oncology

2. **Smith GL**, Shih YT, Xu Y, Giordano SH, Smith BD, Buchholz TA. Breast brachytherapy in the United States: How is this emerging modality being incorporated into the care of older breast cancer patients? Abstract 2008. (Poster presentation: San Antonio Breast Cancer Symposium)

3. **Smith GL**, Shih YT, Xu Y, Giordano SH, Smith BD, Perkins GH, Tereffe W, Woodward WA, Buchholz TA. Racial disparities in treatment for early invasive breast cancer: A national Medicare study of radiotherapy after conservative surgery. Abstract 2008. (Poster presentation: American Society of Clinical Oncology 2008 Breast Cancer Symposium). Highlighted by Medscape Oncology, Reuters, Healthday news, Houston Chronicle, and Houston public radio.

4. **Smith GL**, Smith BD, Giordano SH, Shih YC, Woodward WA, Strom EA, Perkins GH, Oh JL, Tereffe W, Buchholz TA. Risk of hypothyroidism in older breast cancer patients treated with radiotherapy. Abstract 2007 (Poster presentation: American Society for Therapeutic Radiology and Oncology)

5. Roberts KB, Van Hoff J, **Smith GL**, Gurney JG, Kadan-Lottick NS. Radiotherapy for childhood gliomas: possible detriment in long term survival. Abstract 2007 (Poster presentation: American Radium Society).

6. **Smith GL**, Smith BD, Haffty BG. Trends and variation in radiotherapy use for ductal carcinoma in situ (DCIS): achieving a minimal standard. International Journal of Radiation Oncology, Biology, and Physics 60(1) Suppl: S209-10, 2004. (Oral presentation: American Society for Therapeutic Radiology and Oncology)

7. **Smith GL**, Lichtman JH, Krumholz HM. Functional status and quality of life in heart failure patients with renal impairment. Circulation 106(16):e76, 2002 (Abstract).

8. **Smith GL**, Vaccarino V, Kosiborod M, Lichtman JH, Cheng S, Krumholz HM. Worsening renal function: What is a clinically meaningful change in creatinine during hospitalization with heart failure? Journal of the American College of Cardiology 39 (5) Suppl A: Abstract 890-2, 2002. (Abstract) (Oral presentation: Annual meeting for the American College of Cardiology)

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10. **Smith GL**, Havranek EP, Masoudi FA, Wolfe P, Ordin DL, Krumholz HM. Sex and heart failure with preserved systolic function. Journal of Cardiac Failure 7(3) Suppl 1:68, 2001. (Abstract)

11. **Smith GL**, Havranek EP, Masoudi FA, Wolfe P, Ordin DL, Krumholz HM. Sex differences in quality of care for patients with heart failure. Journal of Cardiac Failure 7(3) Suppl 1:76, 2001. (Abstract)

Theses

1. Ph.D.: **Smith GL.** Renal Impairment in Heart Failure: Prevalence, Prognosis, and Detection. 2007.
2. M.D.: **Smith GL.** Patterns of Treatment for Ductal Carcinoma in Situ of the Breast: Rationale for a Minimal Standard. 2005.
3. M.P.H.: **Smith GL**. Social Contact and Hospital Costs in Heart Failure Patients. 2000.
4. B.A. Honors: **Li G**. Race and Resource Utilization by Victims of Domestic Violence: the Houston Area Women's Center. 1998.

Grant Funding

1. Multidisciplinary Postdoctoral Award, Department of Defense Congressionally Directed Medical Research Programs, 2006 Breast Cancer Research Program. Term: July 2007-June 2010. Amount: $692,344. Project title: Patterns of care and disparities in the treatment of early breast cancer.
2. Odyssey Fellow Award, M. D. Anderson Cancer Center. Term: September 2008-September 2010. Project title: Patterns of care for older breast cancer patients.

Certification

11/2006	United States Medical Licensing Examination, Step III, 99 of 99
1/2005	United States Medical Licensing Examination, Step II-Clinical Skills, *pass*
7/2004	United States Medical Licensing Examination, Step II-Clinical Knowledge, 99 of 99
6/2003	United States Medical Licensing Examination, Step I, 99 of 99

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